

**UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEW JERSEY**

ANDY KIM, et al.,

Plaintiffs,

v.

CHRISTINE GIORDANO HANLON, in
her capacity as Monmouth County Clerk,
et al.,

Defendants.

Civil Action No.3:24-cv-1098(ZNQ)(TJB)

**CERTIFICATION OF
DR. SAMUEL S.-H. WANG**

I, Dr. Samuel S.-H. Wang, do hereby certify:

1. I am Dr. Samuel S.-H. Wang, a Professor of Neuroscience at Princeton University.

I have expertise in quantitative neuroscience and statistical analysis of large data sets for scientific hypothesis testing in natural sciences, social sciences, and elections. I previously submitted an Expert Report in this matter (DE1-4), where my curriculum vita was attached, and also submitted an Expert Reply in connection with Plaintiffs' Reply Brief (DE95, Exhibit B).

2. As an expert in quantitative neuroscience and statistical analysis, my experience allows me to apply principles of neuroscience to contextualize how the brain processes information based on visual cues presented in a variety of circumstances, including with respect to ballot design. In turn, my experience allows me to develop potential explanations for how ballot design affects voter behavior, and to develop hypothesis testing via examination of data to control for different variables. Using commonly relied on principles in my field, I am able to apply statistical

analyses to calculate the extent to which the data observed would have occurred by chance, as well as to estimate the size of the effect and compare it with other explanations.¹

Response to Points Raised in Brief in Support of In Limine Motion 1 (ECF Document 152-2)

3. Defense counsel claims that I “began preparing [my] report no later than December 29, 2023 and had discussions regarding this matter with Plaintiffs’ counsel as early as December 18, 2023.” While technically not false, the general gist of this statement is highly misleading, and requires clarification.

4. Plaintiffs’ attorneys scheduled an initial discussion with me for December 21, 2023. I spent approximately one hour of work on the Kim case on December 29, 2023. My work began with a review of my Seton Hall Law Review article on the county line ballot system.

5. In consultation with plaintiffs’ counsel it became apparent that further analysis would require expanded data from Professor Julia Sass Rubin. She had to gather and perform quality control on this data.

6. Once I had more data, I commenced with my work. The next 22.5 hours of work occurred between January 20, 2024 and February 13, 2024. These 22.5 hours constituted 95.7% of the effort that went into producing the eventual expert report. Any claim that I did substantial work on the Kim case before January 20, 2024 and/or the apparent insinuation that I delayed in starting and/or releasing my report to prejudice the Defendants’ time to respond is simply false.

¹ My qualifications, education and professional background, and publication record can be found in my curriculum vita, which is appended to my original report.

7. Once data started to become available from Dr. Rubin, I worked diligently to prepare my report in a timely manner, notwithstanding my other daily professional activities in my capacity as a professor of neuroscience at Princeton University.

Response to Points Raised in Brief in Support of In Limine Motion 4 (ECF Document 155-2)

8. Defense counsel misunderstand the role that neuroscience² plays in my report, mistaking it as a sole basis for reaching conclusions, rather than as an explanation which can then be tested. In other words, the principles of neuroscience and cognitive science discussed in my report tell us what we might expect to be happening when voters are presented with various visual cues on the ballot. While far from mere common sense, these principles, including the concept of

² While it is unclear to what extent my neuroscience and statistical credentials are being challenged, to the extent that it is, I would direct the Court to my CV, and I provide the following additional summary. I have been appointed as Professor of Neuroscience at Princeton University and as an Affiliate for the Center for Statistics and Machine Learning at Princeton University. As explained in my report, “In my academic career I have published over 100 peer-reviewed articles in neuroscience, election science, statistics, and the law of democracy. Nearly all of these articles use statistical testing, including the development of new statistical methods to address specific data problems in the natural sciences and in the study of elections. My neuroscience research addresses how brains learn from sensory experience, and has been published in leading scientific journals including *Nature*, *Neuron*, and the *Journal of Neuroscience*. At Princeton University I have taught extensively in all areas of neuroscience at the undergraduate and graduate level, as well as classes in molecular biology, psychology, and the School of Policy and International Affairs. My research on election science and the law of democracy has been published in leading law and scientific journals including *Proceedings of the National Academy of Sciences*, *Stanford Law Review*, *Election Law Journal*, *Harvard Law and Policy Review*, and the *University of Pennsylvania Journal of Constitutional Law*. I am familiar with electoral statistics in the state of New Jersey: in 2021 and 2022, I served as the technical advisor to the chair of the New Jersey Redistricting Commission, and to the tiebreaking 11th member of the New Jersey Apportionment Commission.” I have over 37 years of research experience as a quantitative neuroscientist. I have received awards for my excellence in neuroscience research from the Alfred P. Sloan Foundation, the W.M. Keck Foundation, the Rita Allen Foundation, and the McKnight Foundation. These are among the nation’s most prestigious research awards that neuroscientists and other biomedical researchers can receive. I have also co-authored two popular books on the brain for lay audiences, and recorded a highly popular set of instructional videos on neuroscience for The Teaching Company.

reliance on cognitive shortcuts, heuristics, and other visual display biases are commonly understood in neuroscience, and have been found to exist in a variety of contexts, including specifically to cognitive behaviors experienced by voters with respect to ballots.

9. However, contrary to what is suggested by defense counsel, my inquiry does not end there. The rest of my report explains how natural experiments, such as those resulting from variations in ballot design across counties and which hold the individual candidate constant, can be used to test certain alternate hypotheses, and to account for various other explanations such as incumbency, candidate funding, endorsement, etc. While one cannot account for and test every variable in every study, the hypothesis testing applied here is commonly relied on in all quantitative sciences to rule out various alternative explanations, making it exceedingly likely to show causal effects to a reasonable degree of scientific certainty, bolstered by use of statistical analyses providing additional clarity on the extent to which the results observed differ from what we could expect to find by chance. That *controlled* experiments have their own separate value in contributing to the body of evidence explaining causal effects and magnitude does not in any way detract from the value of examining such causal effects via the *natural* experiments utilized here. This is especially true given that the natural experiments allowed for review of a large number of contests over a large period of time, which is reflected in the statistical significance testing performed.

10. Defense counsel has misconstrued my application of the scientific process. My report does what expert practitioners of science typically do in their daily work: (a) examine a natural phenomenon, (b) use the principles of their discipline to come up with a plausible explanation, and (c) design tests that would probe that explanation in comparison with other alternative explanations.

11. Defense counsel concedes that the deceptive nature of the county line is “common sense.” Their intuition agrees with the hypothesis I used to begin my analysis: the county line design potentially leads the eye and forces a choice by relying on the brain’s mechanisms of responding strongly to orderly visual patterns. This hypothesis is based on discoveries in visual neuroscience and the cognitive science of decision heuristics, which are described, with citations to the scholarly journal *Science* and the textbook *Social Cognition*. See pages 5-8 of the original expert report. In short, my knowledge of neuroscience allowed me to form a hypothesis that could then be tested statistically.

12. The natural or social scientist’s next step is to find ways to test the hypothesis. Here, I did so by finding natural experiments that could be done with the data to ask the following questions: (a) Could the pattern of wins by candidates on the county line be explained by “endogenous” (i.e. situation-specific) factors such as candidate identity, or county-specific resources? (b) Can the benefit to a candidate of the county line be distinguished from party endorsements? (c) How much can a candidate expect his or her vote share to increase as a result of placement on the county line, compared with a more conventional office-block ballot design of the type used in the other 49 states?

13. Ruling out endogenous explanations is a core problem in the natural and social sciences. Various methods have been devised. Among the most powerful methods is to identify situations where the situation-specific variable (in this case, a specific candidate or county) is held constant, and the factor of interest (in this case the ballot design) is varied. This is a natural experiment, a situation “where the forces of nature or government policy have conspired to produce an environment somewhat akin to a randomized experiment.” Joshua D. Angrist and Alan B. Krueger, *Instrumental Variables and the Search for Identification: From Supply and Demand*

to Natural Experiments, *Journal of Economic Perspectives*, 15(4):69-85, at 73. My analysis of situations where the candidate and/or county were held constant allowed me to rule out a variety of alternative explanations including candidate quality, candidate funding, party endorsement, and county-level party resources and organization.

14. Defense counsel's contention that I do "not profess to have any specialized training in statistical methods," ignores the reality that in the world of science, most expertise in statistics is acquired in a practicing context. I am known as an innovator in statistical data analysis methods, and there are numerous examples of articles where I reported a new method or an application of statistics to a new technical problem, which have been cited to and otherwise relied upon by researchers and other experts in my field.³ Of my most recent ten scholarly publications, four publications use t-tests, chi-square statistics, or both.⁴ Three more publications use statistical methods that are even more advanced, since after all the t-test and the chi-square test are among

³ Some examples include the following:

D.A. Clark, P.P. Mitra, and S.S.-H. Wang (2001) Scalable architecture in mammalian brains. *Nature*, 411:189-193. This article has been cited 337 times.

D.H. O'Connor, G.M. Wittenberg, and S.S.-H. Wang (2005) Initiation of graded bidirectional synaptic plasticity by steplike unitary events. *Proc. Natl. Acad. Sci. USA*, 102:9679-9684. This article has been cited 272 times.

I. Ozden, M.R. Sullivan, H.M. Lee, and S.S.-H. Wang (2009) Reliable coding emerges from coactivation of climbing fibers in microbands of cerebellar Purkinje neurons. *Journal of Neuroscience*, 29:10463-10473. This article has been cited 131 times.

S.S.-H. Wang (2016) Three tests for practical evaluation of partisan gerrymandering. 68 *Stanford Law Review*, 1263-1321. This article, in which I introduced Student's t-test as a way of evaluating partisan gerrymandering, has been cited 140 times.

S.S.-H. Wang (2016) Three practical tests for gerrymandering: application to Maryland and Wisconsin. *Election Law Journal*, 15:367-384. This article, in which I introduced a chi-squared statistic to evaluate partisan gerrymandering, has been cited 54 times.

⁴ As a side note, thirty-two years ago, near the start of my scientific career, in one of my first publications I rederived the chi-squared statistic from first principles in order to develop novel variations of the method, in order to facilitate data analysis during my Ph.D. dissertation. S.S.-H. Wang and S. Thompson (1992) A-type potassium channel clusters revealed using a new statistical analysis of loose patch data. *Biophysical Journal*, 63:1018-1025. That article has been cited thirteen times and its methods have been used by other researchers.

the most elementary of statistical methods, universally known among scientists, and used in countless statistical applications.

15. Having applied commonly used statistical tests, I was able to determine with high scientific confidence that the county line provides benefits that are not found elsewhere in the United States and far exceed those of normal associational rights such as party endorsement. To the extent that there is a “shock value” recognized by defense counsel, it would be as a result of the significant impact of the county line, rather than, as defense counsel suggests, a result of any misapplication of basic, foundational statistical methods and tests.

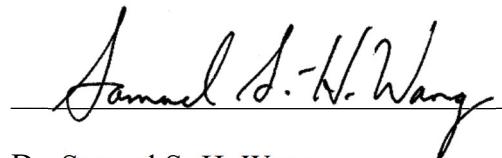
16. Defense counsel also misstates several specific findings of my expert report. On page 13 they claim: “Dr. Wang’s analysis, in reality, only supports the unremarkable conclusion that, on average, primary candidates tend to perform better in counties where they have the endorsement of local elected officials, and that the advantage this endorsement brings fluctuates on a race-by-race basis.” This sentence contains two errors.

17. First, my analysis supports a different claim, one which is in fact remarkable: the county line provides a benefit that surpasses that of a party endorsement alone, thus constituting a “county line bonus.” This county line bonus is 12.2 percentage points on average for all candidates, and 17.1 percentage points on average for nonincumbent candidates.

18. Second, their citation of an average misunderstands the entire discipline of statistical science. Elsewhere, they note that in the Krosnick report in Jacobson v. Lee, that court found that an average difference did not reveal what might happen in an individual instance. However, basic statistical analysis is sufficient to make a prediction using my analysis. The degree to which an individual instance varies around the average 17-percentage-point benefit is measured by a quantity called the standard deviation. This is easily calculated from my work materials which

are in their possession and in the Rubin report, and is 10.1 percentage points. Put another way, my calculation of an average (or arithmetic mean) may be simply a result of adding up the total benefits observed in n races and dividing that total by n . However, my report is premised on the significance of the data based on the electoral benefits observed in *each* of the individual races, *and* their variation from the average (*i.e.*, the standard deviation), not just the average alone. Since the issue was raised by defense counsel in this motion, it is worth noting that based on the average *and* the standard deviation, it can be inferred that a nonincumbent on the line with a party endorsement would outperform a party endorsement alone in 94 out of 100 instances. Furthermore the “county line bonus” would be larger than 5 percentage points in 87 out of 100 instances. Therefore it is overwhelmingly likely that in any one election, the benefit to a nonincumbent candidate on the line would exceed the range of effects that have been observed in past peer-reviewed research on primacy effects.

I declare under penalty of perjury that the foregoing statements are true and correct to the best of my knowledge and belief. Executed at Princeton, New Jersey, on the 22nd day of March, 2024



Samuel S.-H. Wang

Dr. Samuel S.-H. Wang